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DESCRIPTION

IMAGE INPUT APPARATUS

Technical Field

The present invention relates to an image input apparatus and, more particularly, to a structure for effectively reducing stepwise differences in density between chips in an image sensor of an image scanner.

Background Art

Conventionally, in an image scanner which requires a large image sensor for reading a relatively large object, such as a desktop type, plural chips of the same standard are arranged adjacently and an image of the object is read by employing output signals from the respective chips. The image scanner having such a structure initially measures gamma characteristics for each chip and compensates each gamma compensation value for each corresponding chip when an image is inputted, thereby resolving manufacture variations among the respective chips to obtain a fine image.

However, when chip characteristics are varied due to changes over time or the like, it is necessary to measure and compensate the gamma characteristics on all such occasions. In addition, when there are different gamma characteristics within

one chip, the effect appears in an image as the stepwise difference in density on the chip boundary, and such a case cannot be handled by this structure. Further, it is required to provide many memories on the scanner side to store gamma compensation values for plural chips.

The conventional image input apparatus is so constructed, and labor involved in the maintenance of plural sensor chips for compensation of gamma characteristics due to the secular change and many memories for storing gamma compensation values are necessary. Further, when there are different gamma characteristics within one chip, this cannot be handled, whereby a fine image cannot be obtained.

The present invention is made to solve the above-described problems and has for its object to provide an image input apparatus which does not require maintenance such as a gamma characteristics compensation of a sensor chip due to the secular change and can perform the compensation of gamma characteristics within one chip.

Disclosure of the Invention

According to Claim 1 of the present invention, in an image input apparatus having an image reading unit which is constructed by arranging plural chips integrally, a stepwise difference in density between image signals which are respectively read by adjacent chips consisting of plural read

pixels, which chips have different reading sensitivities, is successively calculated at a time of image reading, and the image signals which are respectively read by the adjacent chips are compensated such that the difference in density between the image signals is compensated.

According to Claim 2 of the present invention, the image input apparatus of Claim 1 has a gamma compensation value only for one chip among the plural chips as a reference, and compensates the image signals for the chip as the reference and other chips by employing the gamma compensation value.

According to Claim 3 of the present invention, in the image input apparatus of Claim 2, the stepwise difference in density of the image signals between the adjacent chips is calculated for image data which has been subjected to the compensation of the image signals by employing the gamma compensation value, and the stepwise difference in density is uniformly added to chips except for the chip as the reference.

According to Claim 4 of the present invention, in the image input apparatus of Claim 2, the stepwise difference in density of the image signals between the adjacent chips is calculated for image data which has been subjected to the compensation of the image signals by employing the gamma compensation value, and the stepwise difference in density is added to respective pixels in stages for chips except the chip as the reference from the end of the chips.

According to Claim 5 of the present invention, in the image input apparatus of any of Claims 1 to 4, in calculation of the stepwise difference in density between the image signals, a difference of pixel data on the chip boundary is taken as the stepwise difference in density between the image signals.

According to Claim 6 of the present invention, in the image input apparatus of Claim 5, in the calculation of the stepwise difference in density between the image signals, a mean of differences of pixel data on chip boundaries for several lines is taken as the stepwise difference in density between the image signals.

According to Claim 7 of the present invention, in the image input apparatus of Claim 6, in the calculation of the stepwise difference in density between the image signals, in a case where the mean of the differences of the pixel data on the chip boundaries for several lines is calculated, when the difference exceeds a threshold value, the difference value is excluded from the calculation of the mean.

According to Claim 8 of the present invention, in the image input apparatus of Claim 6, in the calculation of the stepwise difference in density between the image signals, the calculation of the stepwise difference in density between the image signals is started after being delayed from a real reading start by the number of lines which are required for calculating the mean value of the stepwise differences in density between

the image signals.

According to Claim 9 of the present invention, in the image input apparatus of Claim 8, the calculated stepwise difference in density is added from a first line of read image data, and last lines, by the number of which lines the calculation of the stepwise difference in density has been delayed, are not processed.

According to Claim 10 of the present invention, in the image input apparatus of Claim 8, the calculated stepwise difference in density is added from a first line of read image data, and last lines, by the number of which lines the calculation of the stepwise difference in density has been delayed, are subjected to addition with a lastly calculated stepwise difference in density.

According to Claim 11 of the present invention, in the image input apparatus of Claim 8, the calculated stepwise difference in density is added starting from a line of the read image data, delayed by the number of lines which are required for calculating the stepwise difference in density, and the lines from the start, by the number of which lines the calculation is delayed, are not processed.

According to Claim 12 of the present invention, in the image input apparatus of Claim 8, the calculated stepwise difference in density is added starting from a line of the read image data, delayed by the number of lines which are required

for calculating the stepwise difference in density, and an initially calculated stepwise difference in density is added to the lines from the start, by the number of which lines the calculation is delayed.

According to Claim 13 of the present invention, in the image input apparatus of any of Claims 1 to 12, when real-time screen display of an input image is performed, the screen display is performed from a line which has been subjected to the addition of the stepwise difference in density between the chips.

According to Claim 14 of the present invention, in the image input apparatus of Claim 13, the calculated stepwise difference in density is added from a first one of the read lines, when last several lines are not processed, display is performed on a screen from the first line, and the last several lines which are not processed are not displayed on the screen.

According to Claim 15 of the present invention, in the image input apparatus of Claim 13, when the calculated stepwise difference in density is added from a line delayed by several lines, the line delayed by the several lines to the last line are displayed on the screen.

According to Claim 16 of the present invention, the image input apparatus of Claim 1 comprises: a density stepwise difference correcting means for, when the calculated stepwise difference in density is compared to a predetermined threshold

value and the calculated stepwise difference in density is larger than the threshold value, correcting the calculated stepwise difference in density.

According to Claim 17 of the present invention, in the image input apparatus of Claim 16, the density stepwise difference correcting means makes the stepwise difference in density 0 when the stepwise difference in density is larger than the threshold value, thereby correcting the calculated stepwise difference in density so as not to perform compensation of the stepwise difference in density between the image signals.

According to Claim 18 of the present invention, in the image input apparatus of Claim 16, the density stepwise difference correcting means holds the stepwise difference in density at a predetermined value so as not to be larger than the threshold value when the stepwise difference in density is larger than the threshold value.

According to Claim 19 of the present invention, in the image input apparatus of Claim 16, the density stepwise difference correcting means calculates the difference with increasing the number of lines of pixels in chips for calculating the stepwise differences in density when the stepwise difference in density is larger than the threshold value.

According to Claim 20 of the present invention, in the image input apparatus of Claim 1, the stepwise difference in

According to Claim 24 of the present invention, in the image input apparatus of Claim 21, the stepwise difference in density between the image signals is compensated by applying to a stepwise difference in density of an intermittent region which is not a target to be read, a stepwise difference in

density of a region which has been read immediately before the target region, at the prereading.

As described above, according to an image input apparatus of the present invention, in an image input apparatus having an image reading unit constructed by arranging plural chips integrally, a stepwise difference in density between image signals respectively read by adjacent chips consisting of plural read pixels, which chips have different reading sensitivities, is successively calculated at the time of image reading, and the image signals which are respectively read by the adjacent chips are compensated such that the stepwise difference in density between the image signals is compensated. Therefore, the stepwise difference in density on the chip boundary resulting from the changes over time or the difference of gamma characteristics within one chip can be made inconspicuous without making the user conscious.

Further, according to the image input apparatus of the present invention, this apparatus has a gamma compensation value only for one chip among the plural chips as a reference, and compensates the image signals for the chip as the reference and other chips by employing the gamma compensation value. Therefore, it is only required that the apparatus should hold only a gamma compensation value for one chip as the reference, thereby saving necessary memory.

Further, according to the image input apparatus of the

present invention, the stepwise difference in density of the image signals between the adjacent chips is calculated for image data which has been subjected to the compensation of the image signals by employing the gamma compensation value, and the stepwise difference in density is uniformly added to chips except for the chip as the reference. Therefore, the stepwise difference in density between the chips can be reduced by a simple operation.

Further, according to the image input apparatus of the present invention, the stepwise difference in density of the image signals between the adjacent chips is calculated for image data which has been subjected to the compensation of the image signals by employing the gamma compensation value, and the stepwise difference in density is added to respective pixels in stages for chips except the chip as the reference from the end of the chips. Therefore, even when a difference of the compensation values between the pixels which exist between the adjacent chips is large and the gamma characteristics greatly vary within one chip, the compensation is not performed excessively, whereby more natural compensation of gamma characteristics can be performed.

Further, according to the image input apparatus of the present invention, in calculation of the stepwise difference in density between the image signals, the density stepwise difference calculation means takes a difference of pixel data

on the chip boundary as the stepwise difference in density between the image signals. Therefore, the stepwise difference in density on the chip interface can be effectively resolved.

Further, according to the image input apparatus of the present invention, in the calculation of the stepwise difference in density between the image signals, a mean of differences of pixel data on chip boundaries for several lines is taken as the stepwise difference in density between the image signals. Therefore, a smoother compensation of the stepwise difference in density can be performed, and it can be expected to obtain a fine read image.

Further, according to the image input apparatus of the present invention, in the calculation of the stepwise difference in density between the image signals, in a case where a mean of differences of pixel data on chip boundaries for several lines is calculated, when the difference exceeds a threshold value, the difference value is excluded from the calculation of the mean. Thereby, an error of the mean value due to an abnormal value or the like can be reduced.

Further, according to the image input apparatus of the present invention, this apparatus comprises a density stepwise difference correcting means for, when the calculated stepwise difference in density is compared to a predetermined threshold value and the calculated stepwise difference in density is larger than the threshold value, correcting the calculated

stepwise difference in density. Therefore, there can be provided an image input apparatus with high reliability, without using a stepwise difference in density resulting from miscalculation for the compensation of characteristics between the chips.

Further, according to the image input apparatus of the present invention, a stepwise difference in density is calculated at prescanning which is performed before real scanning, and the stepwise difference in density is used for compensating image signals at the real scanning. Therefore, the processing at the real scanning can be speeded up.

Brief Description of the Drawings

Figure 1 is a diagram illustrating a structure of an image input apparatus according to a first embodiment of the present invention.

Figures 2 are diagrams for explaining a method for calculating the stepwise difference in density by the image input apparatus.

Figures 3 are diagrams for explaining a method in a case where stepwise differences in density are averaged and an average difference is uniformly added to chips by the image input apparatus.

Figure 4 is a diagram for explaining a method in a case where stepwise differences in density are averaged and an

average difference is added to chips in stages by the image input apparatus.

Figure 5 is a diagram illustrating a structure of an image input apparatus according to a second embodiment of the present invention.

Best Mode for Carrying out the Invention (Embodiment 1)

Hereinafter, an image input apparatus according to a first embodiment of the present invention will be described.

Figure 1 is a block diagram of the image input (reading) apparatus according to the first embodiment. In the figure, numeral 1 denotes an image scanner, and numeral 11 denotes a personal computer (PC) for compensating a stepwise difference in density which realizes a density stepwise difference calculating means and a density stepwise difference compensating means. Numeral 12 denotes a display apparatus (CRT) for displaying a read image.

Further, an image sensor 2 constituting the image scanner 1 consists of a chip 3 and a chip 4 which are arranged side by side in a direction orthogonal to the scanning direction, and amplifiers 5 and 6 amplify and output outputs from the chips 3 and 4, respectively.

The outputs of the amplifiers 5 and 6 are converted into digital data by an ADC (analog-digital converter) 7 in the

latter stage. A shading compensation unit 8 performs a shading compensation for digital-converted data by using a shading coefficient of a RAM 10, and further a gamma compensation unit 9 performs gamma compensation using a gamma coefficient of the RAM 10.

Thereafter, the data is transferred to the PC 11, the density stepwise difference compensation is performed in the PC 11, and thereafter the read-in image is displayed on the CRT 12.

Next, the operation of the image input apparatus according to the first embodiment will be described with reference to figures 1 to 4.

Initially, one of the chips 3 and 4 is used as the reference and a gamma compensation value of the chip is stored in the RAM 10. For example, when the chip 3 is used as the reference, the gamma compensation value of the chip 3 is stored in the RAM 10, and the gamma compensation unit 9 performs gamma compensation for both of the chips 3 and 4 by using the gamma compensation value of the chip 3 which value is stored in the RAM 10.

Next, a stepwise difference in density is calculated from pixel data on the boundary after performing the gamma compensation for the chips 3 and 4. In figure 2(a), assume that 322 pixels from P_1 to P_{322} line up in the chip 3, and 322 pixels from P_{323} to P_{644} line up in the adjacent chip 4, that is, 644 pixels in total line up. Boundary pixels of the chips 3 and

4 are the pixel P_{322} and the pixel P_{323} , and a density stepwise difference S between the chips 3 and 4 is obtained by the following Formula (1).

$$S = P_{322} - P_{323} \quad \text{Formula (1)}$$

Further, as shown in figure 2(b), the calculated stepwise difference S in density is uniformly added to the pixels P_{323} to P_{644} according to Formula (2), so that the stepwise difference in density between the chips can be made inconspicuous.

$$P_{323}' = P_{323} + S \quad \text{Formula (2)}$$

$$P_{324}' = P_{324} + S$$

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$$P_{644}' = P_{644} + S$$

Further, when the stepwise difference in density is calculated only by the read pixels P_{322} and P_{323} , there is a case where a correct stepwise difference in density cannot be calculated due to influence of noise. Further, since P_{322} and P_{323} are disposed individually, there are deviations in the physical read positions, whereby the stepwise difference in density originally existing on a manuscript may be calculated as the stepwise difference in density between the chips.

Then, the stepwise differences in density are calculated on several lines by vertical scanning and the calculated stepwise differences are averaged, thereby reducing an error in the calculation results. In figure 3(a), for example, when

the number of lines for calculating a mean value is n , the respective density stepwise differences $S_1 \sim S_n$ of the lines $L_1 \sim L_n$ are calculated by the Formula (1), thereby obtaining a mean value by the following Formula (3) on the basis of this result.

$$m_1 = (S_1 + S_2 + \dots + S_n) / n \quad \text{Formula (3)}$$

The mean value m_1 as the obtained result is uniformly added to the pixels P_{323} to P_{644} as shown in figure 3(b). With respect to the next line L_2 , a mean value m_2 of the stepwise differences in density of the lines L_2 to L_{n+1} is calculated as shown in figure 3(c), and the mean value m_2 as the obtained result is uniformly added to the pixels P_{323} to P_{644} as shown in figure 3(d). In this way, with respect to all the lines, a mean value of the stepwise differences in density of n lines starting from a target line is obtained and the mean value is added to a density value of the target line.

Here, in a case where there are excessive stepwise differences in density in some lines, the mean value of the stepwise differences in density is compared with a predetermined value or the like, whereby no addition is performed when the mean value of the stepwise differences in density is calculated, thereby enhancing the accuracy of a density stepwise difference compensation.

Further, as another addition method for adding the value of the stepwise difference in density to one chip to compensate the stepwise difference in density, there is a method by which

the value is added in stages over several pixels of the chip 4. As an example, a method by which the value is added in stages for 10 pixels assuming that the chip 4 is composed of 10 pixels will be described with reference to figure 4.

As described above, the mean value m is calculated, and this calculated mean value m is added to the pixels P_{323} to P_{332} with decreasing a value (a compensation value) in stages from the pixel P_{323} to the pixel P_{332} . By performing the compensation according to this method, for example even when the difference of the gamma characteristics of the pixels which are close to the boundary between the adjacent chips is large, variations of the gamma characteristics within one chip are small, and an excessive compensation is not performed when a value to be compensated of a pixel in a slightly distant position is smaller than that of a pixel existing on the chip boundary, whereby the compensation process can be performed in stages in a natural manner. When this is formulated, 10 pixels from the pixel P_{323} to the pixel P_{332} are represented by the following Formula (4).

$$P_{323}' = P_{323} + (m/10) * 10 \quad \text{Formula (4)}$$

$$P_{324}' = P_{324} + (m/10) * 9$$

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$$P_{332}' = P_{332} + (m/10) * 1$$

In order to calculate a mean of the stepwise differences in density as described above, the compensation process for a

target line should be performed with being delayed by n lines which are required to calculate the mean. When this process is performed, the last n lines are used only for obtaining the mean, and thus the mean of the stepwise differences in density of the target line cannot be calculated. Then, a processing such as abandoning data of the last n lines even when the data are read, adding the same value as the mean value m which is lastly calculated before the process is performed to the last n lines, or decreasing the number of lines whose mean is calculated in stages is performed.

Further, when the mean value m for the first n lines is added to L_n , contrary to the above-described method, a mean of the stepwise differences in density for the first n lines cannot be calculated. Then, it is possible that data of the first n lines are abandoned, the same value as the mean value m which is initially calculated as a mean of the stepwise differences in density is added to each of the first n lines, or the number of lines whose mean is calculated is increased in stages up to line n .

In a case where a read image is displayed on a screen in real time by employing an image reading apparatus which comprises the above-described structure for performing the density stepwise difference compensation process, data is displayed successively from a line for which the density stepwise difference compensation process has been completed,

Further, also with respect to the display image, as described above, when the first n lines are abandoned the first n lines are not displayed, and when the last n lines are abandoned conversely the last n lines are not displayed.

By performing the processing as described above, the stepwise difference in density between the chips can be made inconspicuous by few memories without the maintenance for the density stepwise difference compensation which should be performed by the user.

As described above, according to this embodiment, the stepwise difference in density between pixels which are positioned in adjacent places to the adjoining chips 2 and 3 of the image sensor is obtained for plural lines and averaged, the stepwise difference in density between the chips is compensated for each line by employing each of the obtained mean values, and thereafter the image is read. Therefore, it is only required to provide a memory that holds the gamma compensation value for one chip as the reference for the density stepwise difference compensation, thereby suppressing an increase in the memory. Further, the density stepwise difference between the chips can be always compensated regardless of the secular change without troubling the user. In addition, variations of the

gamma characteristics within one chip can be also compensated, whereby a good read-in result can be obtained.

Further, the compensation value is varied in stages according to the number of adjacent pixels for the chips except for a chip as the reference, thereby compensating the stepwise difference in density more naturally.

(Embodiment 2)

Next, an image input apparatus according to a second embodiment of the present invention will be described.

Figure 5 is a block diagram of the image input apparatus according to the second embodiment of the present invention. In the figure, numeral 11a denotes a PC (personal computer) which realizes a density stepwise difference correcting means as well as the density stepwise difference calculating means and the density stepwise difference compensating means.

Hereinafter, the operation will be described. While the basic operation is the same as that of the first embodiment, the mean of the stepwise differences in density is calculated using Formula 3 and thereafter it is judged whether or not the calculated density stepwise difference exceeds a predetermined value in the PC 11a having the density stepwise difference correcting means. When the calculated value exceeds the predetermined value, it is judged that the value is obtained as a result of a miscalculation or other factors, and the compensation amount is corrected to an appropriate value.

What is first considered as the cause of this miscalculation is a case where the calculated density stepwise difference is one which originally exists on the manuscript, and in this case the density stepwise difference is corrected to 0 and the compensation is not performed.

What is secondly considered is a case where the calculated density stepwise difference is generated due to influence of noise or the like, and in this case the density stepwise difference is corrected to the same value as a prescribed value and the image deterioration caused by performing compensation with a larger value than the prescribed value is prevented. Further, the number of lines for calculating the mean is increased and the calculation is performed again, whereby the error in the calculation results is reduced, thereby preventing the image deterioration.

By performing the processing as described above, it can be prevented that an unnecessary compensation is performed because of a stepwise difference in density due to miscalculation, thereby causing the image deterioration.

(Embodiment 3)

Next, an image input apparatus according to a third embodiment of the present invention will be described.

In this embodiment, the calculated difference in density is employed at the start of reading, and the compensation of image signals in subsequent reading following the start of the

reading is performed.

That is, a difference of characteristics in each chip does not vary during the reading operation, and thus after the density stepwise difference in each chip is calculated at the start of reading, the image signals which are read thereafter can be compensated by using the calculated value.

As described above, the stepwise difference in density calculated at the start of reading is employed for image signal compensation at the time of subsequent reading processes, thereby increasing a processing speed as compared with the method by which the stepwise difference in density is calculated in real time for each read line to perform the compensation of the image signals.

(Embodiment 4)

Next, an image input apparatus according to a fourth embodiment of the present invention will be described.

In the fourth embodiment, assume that a reading process is performed at high speed before reading data with degrading the resolution as compared with a real reading, that is, the so-called prescanning process is performed. This prescanning process is a known process which is normally performed for deciding a read range of image data before actually reading the image. In the image input apparatus having such a prescanning function, the stepwise difference in density is previously calculated at the prescanning, whereby it can be expected to

increase the processing speed at real scanning.

Here, in the prescanning, unlike in the real scanning, all image data are not read but the image data are thinned and read. Therefore, the mean of the density stepwise differences of the respective lines, which differences are calculated at the prescanning, is calculated, and at real scanning the compensation is performed only by that value.

Further, the density stepwise differences of the respective lines, which differences are calculated at the prescanning, are stored in a storage device (here, PC11 or PC11a), and at the real scanning the compensation is performed by the stored density stepwise differences of the respective lines. At this time, since the stored density stepwise differences are ones for the image data which have been thinned for the prescanning, the calculated density stepwise differences themselves are also in a thinned state. Thus, in a part having no data, that is, a region where image data are thinned (practically in line units), the compensation is performed with reference to data of the immediately preceding line.

As described above, according to this embodiment, the stepwise difference in density between the chips is calculated at the prescanning and employed at the real scanning, thereby increasing the processing speed at the real scanning.

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